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Aggregate Resources Inventory of Holland Township

Grey County
Southern Ontario

By Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

1985

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This report was prepared by: Staff of the Aggregate Assessment Office, Engineering and Terrain Geology Section of the Ontario Geological Survey, Ontario Ministry of Natural Resources, 77 Grenville Street, Toronto M5S 1B3, Telephone (416) 965-1182.

Project Supervisor: Dale W. Scott and I. Szoke
Field Work and Report by: D. Tennant
Compilation and Drafting by: Staff of the Aggregate Assessment Office

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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Aggregate Resources Inventory of Holland Township Grey County

by
Staff[1] of the Engineering and Terrain Geology Section

1. Project supervisor: Dale W. Scott and I. Szoke; field work and report by D. Tennant; compilation and drafting by staff of the Aggregate Assessment Office. The Mineral Resources Staff of Owen Sound District and Southwestern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

This report includes both an inventory and evaluation of sand and gravel, as well as bedrock resources, in Holland Township. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Pits and Quarries Control Act.

Two areas containing good quality, outwash gravel have been selected for possible resource protection at the primary level of significance. The selected areas constitute the most important natural aggregate sources in Holland Township. In addition, a number of ice-contact, outwash and esker deposits have been selected as resources of secondary significance. Although these secondary deposits are not considered the "best" resources, they should be considered part of the township's aggregate supply.

The Primary Resource Areas in Holland Township cover 2100 acres (850 ha), exclusive of licenced properties. An estimated 1700 acres (690 ha) are available for extraction, containing possible resources of 60 million tons (54 million tonnes) of sand and gravel. The available parts of the selected areas represent 9 percent of the total area of sand and gravel deposits in the township and 11 percent of the original tonnage.

The Guelph Formation underlies most of Holland Township except the north-central and northeastern parts where the successively older Amabel, Fossil Hill, Cabot Head, Manitoulin, and Queenston Formations occur. The thinnest drift cover is generally found in the northern part of the township where a number of outcrops of the Amabel and Guelph Formations occur. The Amabel Formation is a valuable potential source of crushed stone, concrete aggregate, building stone, and raw material for the manufacture of lime. In areas where the drift cover is less than 25 feet (8 m), the formation has been selected for possible resource protection. The Selected Bedrock Resource Areas cover approximately 4700 acres (1900 ha), 3750 acres (1520 ha) of which are available for extraction. The available areas contain an estimated 810 million tons (740 million tonnes) of bedrock resources. The other formations are not well suited for the production of load-bearing aggregate, although the Guelph Formation can be a valuable source of dolomitic lime.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

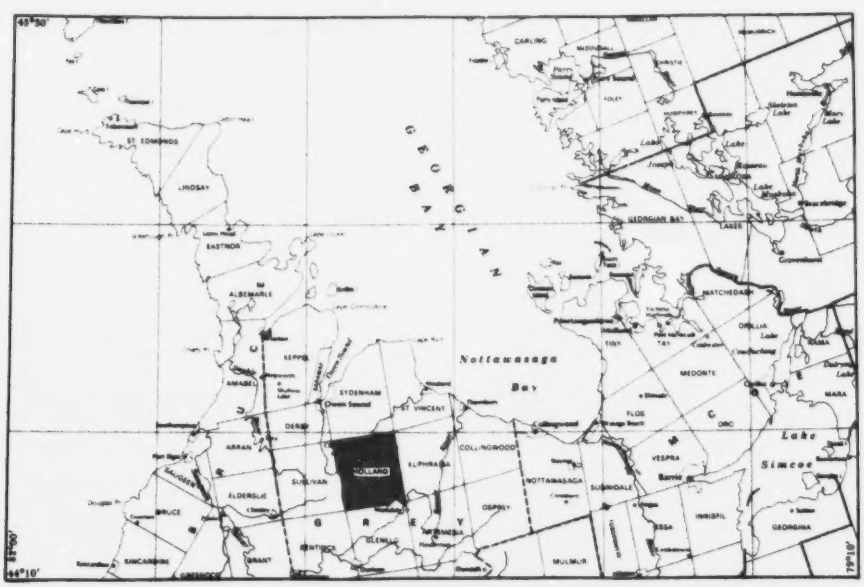


Figure 1. Key Map Showing the Location of Holland Township.
Scale 1:1 800 000

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregates extracted was 101 million tons (92 million tonnes), greater than that of all other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1983).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential of bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing, hand augering and geophysical techniques are used to assess subsurface materials. Airphotos at various scales are used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100- pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution and in some cases Los Angeles abrasion, absorption, and Magnesium Sulphate soundness tests along with petrographic analyses are performed.

Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey. In areas of limited subsurface exposure, test holes are drilled and geophysical surveys using hammer seismic equipment are undertaken. The symbols for and locations of sample and test hole sites along with geophysical traverse lines are noted on Map 1.

In the office, the field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps, and from the interpretation of water well records. The

measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tons of a one-foot (0. 3 m) thick section of rock, one acre (0.4 ha) in extent).

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg per cubic metre) or 3600 tons per acre (8070 tonnes per hectare). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

Part II — Data Presentation and Interpretation

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

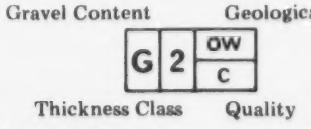
Map 1 is derived from existing surficial geology maps of the area or from airphoto interpretation in areas where surficial mapping is incomplete. The map shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, gravel deposits are indicated by dark brown shading while sand deposits are shaded light brown. The present level of extractive activity is also indicated. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The information from which these symbols are derived has been plotted in grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol. Geophysics lines are shown on the map by a line symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by dark shading on Map 2.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light red shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Al-

though deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the litholgy of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes, pits or sample sites have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on ex-

tractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalites with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three shades of blue. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas consitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource ares. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected drill hole which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approch. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Part III — Assessment of Aggregate Resources in Holland Township

LOCATION AND POPULATION

Holland Township occupies 70,934 acres (28 707 ha) in the north- central part of Grey County, southern Ontario. The township is shown on the Markdale (41 A/7) map sheet of the National Topographic System at a scale of 1:50 000.

The population of the township, excluding the Village of Chatsworth, has increased 13 percent since 1972 to a total of 2222 in 1982 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The township supports mainly farming activities, with livestock production being the dominant agricultural land use. There is also a significant number of rural-residential inhabitants.

The Village of Chatsworth, which is located along King's Highway 6 in the northwestern part of the township is a local trade and retail centre. Its population was 410 in 1982 and has increased only four percent since 1972 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Several smaller settlements including Holland Centre, Berkeley, Walters Falls, and Williamsford also provide local services to the surrounding rural population.

The township is also located near the City of Owen Sound and the Village of Markdale. The City of Owen Sound is situated approximately 13 km north of Chatsworth on King's Highway 6. The city, with a population of 19 624 in 1982, serves as a commercial, industrial and institutional centre on a regional level (Ontario Ministry of Municipal Affairs and Housing 1983). The Village of Markdale is located just south of the township on King's Highway 10.

Access within the township is provided by King's Highway 6, which forms the township's western boundary, and King's Highway 10, which runs northwest-southeast through the area. Various county and township roads also provide connecting links within the township. In addition, a line of the Canadian Pacific Railway traverses the township along King's Highway 10.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including sand and gravel deposits, are primarily the result of glacial activity which took place during the Late Wisconsinan Substage of the Pleistocene Epoch, informally known as the "Great Ice Age". During this substage, which lasted from approximately 23 000 to 10 000 years ago, lobes of the Laurentide continental ice sheet advanced out of the basins of the Great Lakes and joined together to cover southern Ontario. The lateral extent of the ice lobes and the positions of their margins underwent numerous fluctuations until approximately 10 000 years ago when the ice finally melted back and completely disappeared.

A strong advance of the Georgian Bay lobe of the continental ice sheet formed a landscape of drumlinized ground moraine throughout Holland Township (Feenstra, in prep.). The ground moraine predominantly consists of coarse gravelly till which is unsuitable for use as aggregate because it contains excessive fines. The drumlins are generally streamlined, elongated hills which are oriented roughly north-south in the area, parallel with the direction of the ice movement (Feenstra 1975). In places, the drumlins are covered by younger sediments.

Drumlins are particularly abundant in the Bighead Valley physiographic region (Chapman and Putnam 1966). The Bighead Valley is a steep-sided reentrant in the Niagara Escarpment, which existed prior to glaciation and was further deepened by glacial erosion. The head of the valley is located in the area between Massie and Strathavon in northern Holland Township.

The remaining area in the township is included in the Horseshoe Moraines physiographic region (Chapman and Putnam 1966). As the ice retreated in this area, a considerable amount of the ground moraine was covered by end moraine, ice-contact, esker, outwash and glaciolacustrine plain sediments. The end moraines deposited in the area include the Singhampton, Gibraltar, Banks, Williscroft and Tara Moraines. (The name Gibraltar Moraine was proposed by Feenstra (1975) and Sharpe (1975) as part of the reclassification of the Port Huron Moraine system and was formerly known as the Singhampton Moraine (Chapman and Putnam 1966)). These generally east-west trending moraines delineate the positions of the ice front as the ice sheet melted back through Holland Township. They are complex, hummocky features consisting of varying amounts of till and ice- contact sand and gravel. The Gibraltar and Banks Moraines are considerably larger than the Tara Moraines which occur as thin strands north of the Banks Moraine. Only those sections of the moraines which are known to contain sand and gravel are delineated on Maps 1 and 2. Although the moraines may contain large volumes of aggregate, they are not considered to be the best aggregate sources in the township.

Several eskers and ice-contact deposits, which are not directly associated with the moraines, were deposited in the area. The eskers were deposited by meltwaters flowing through tunnels or crevasses in the ice, forming long sinuous ridges on the present-day land surface. The ice-contact stratified drift was deposited near the ice margin in complex sedimentary environments. Both these deposit types contain stratified sand and gravel and several pits have been developed in them.

Outwash deposits are also common in the township. They were deposited by meltwater streams flowing beyond the ice margin and largely consist of well stratified sand and gravel. A number of these deposits, specifically the outwash associated with the Gibraltar Moraine near Berkeley and the outwash in the vicinity of Robson Lakes, are considered important sources of good quality aggregate.

During the formation of the Tara Moraines, meltwaters ponded in short-lived proglacial lakes north of the Banks Moraine. These patchy deposits generally consist of silty fine sand or clay and silt, and are not

well suited for most aggregate uses. Parts of the Bighead Valley are also occupied by fine-grained glaciolacustrine sediments.

Postglacial erosional and depositional processes have been of minor importance in modifying the physiography of Holland Township. A postglacial deposit of marl occurs at Bells Lake. Marl was used at the turn of the century for the manufacture of portland cement. Today the most likely market for this material is for use as an industrial filler (Feenstra, in prep.).

EXTRACTIVE ACTIVITY

In 1972, Holland Township was designated under the Pits and Quarries Control Act. Prior to that time, numerous small pits had been active in the township. Presently, there are 77 pits identified in the township. The Ontario Ministry of Transportation and Communications (M.T.C.) has rated the quality of the aggregate available from 38 of these pits. Twenty-eight of the pits tested are considered to be moderate to moderate-high quality aggregate sources, indicating that they are, or were, capable of producing crushed aggregate for use in Granular Base Course (G.B.C.) A, and in some cases for hot-laid asphaltic stone (Deike 1982). The remaining 10 pits are rated as being capable of producing G.B.C. B and C in large quantity, and in some cases G.B.C. A (Deike 1982).

In Holland Township, there are currently six pits licenced for extraction under the Pits and Quarries Control Act. The total area of these licenced properties is 495.9 acres (200.7 ha). From 1975 to 1982, the average annual licenced production from Holland Township was 49,862 tons (45 235 tonnes). Average annual wayside production for the same period of time was 120,710 tons (109 508 tonnes). Wayside pits are temporary sources operating on demand under authority of a permit for purposes of road construction.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the deposits which contain granular materials. The total extent of these deposits is approximately 19,300 acres (7800 ha), representing an original tonnage of 560 million tons (510 million tonnes). Many of these deposits have limited value for reasons of the extent, quality, workability or availability of the material. Consequently, only the most significant sources are suggested for possible resource protection.

The major constraint affecting the quality of the aggregate in the area's pits is the presence of soft, porous dolostone. This material occurs in varying amounts throughout Holland Township, generally ranging from 2 to 20 percent in the pits (Deike 1982). Excessive quantities of this material can restrict the use of the aggregate for hot-laid asphalt and structural concrete.

An excessive amount of fines has also been noted in some of the pits in the township (Deike 1982). The fines limit high- specification use of the material without extensive processing. Clay and silt seams as well as zones of cemented gravel have also been observed in several pits. The presence of these materials would necessitate selective extraction procedures. In addition, a number of pits contain insufficient quantities of crushable gravel which would also restrict high-specification use of the aggregate. In several low-lying areas, high water tables may inhibit extraction.

The highest quality aggregate in Holland Township is generally found in the outwash deposits located between the major moraines which traverse the township. Two areas of outwash gravel have been selected for possible resource protection at the primary level of significance. The Primary Resource Areas cover approximately 2100 acres (850 ha), exclusive of licenced properties. An estimated 1700 acres (690 ha) are available for extraction containing a total tonnage of 60 million tons (54 million tonnes). The available parts of the selected areas represent 9 percent of the total area of sand and gravel deposits in the township and 11 percent of the original tonnage.

Several outwash, ice-contact and esker deposits have been designated as resources of secondary significance. Although these deposits may have some quality and workability problems, they add considerably to the resource base of the township and should be considered a part of the total aggregate supply.

The remaining resources have been classified at the tertiary level and represent deposits which have appreciable quality and workability problems and/or contain low available resources. Also, in several of these deposits quality data are lacking and extensive testing is required to establish the extent of usable aggregate. Future exploration concerning the tertiary deposits may enlarge the township's aggregate supply.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is located south of Berkeley, in southern Holland Township. The area consists of two outwash gravel deposits, labelled 1a and 1b on Map 2. Together the areas occupy approximately 1060 acres (430 ha).

Area 1a is the larger of the two deposits. Although there are no licenced pits in the deposit, it does contain four unlicenced pits (pit nos. 64, 65, 71, and 72). Face heights in these pits varied from 5 to 12 feet (1.5 to 4 m). The estimated gravel content in the pits ranged from 40 to 75 percent, with the exception of pit no. 72 which contained 5 to 40 percent gravel.

During field investigation, a sample was taken from pit no. 64. Analysis of the sample showed that it contained 73 percent gravel, 25 percent sand and 2 percent fines (Figure 2a). The M.T.C. has also tested the pit and reports that it contains high quality gravel generally suitable for hot-laid asphalt and structural concrete uses (Deike 1982). In addition, the material is acceptable for use as granular base course and 16 mm Crushed A and B. The sand fraction of the aggregate would require blending for hot-laid asphalt. Test holes placed by M.T.C. in the vicinity of pit no. 64 indicate the presence of considerable quantities of crushable gravel with similar use capabilities as those described for the pit.

Area 1b contains unlicenced pit no. 66. Five- to twenty-foot (1.5 to 6 m) faces were present in the pit exposing between 50 and 75 percent gravel. Most tests performed by M.T.C. on the material in the pit reveal

the presence of good quality gravel similar to that exposed in pit no. 64 (Deike 1982). A few of the tests, however, indicate that poorer quality sections, unsuitable for use as hot-laid asphalt, exist. Therefore, selective extraction procedures would be required for this use.

Similar quality material to that exposed in pits within Areas 1a and 1b may be available from the currently undeveloped parts of the deposits. Geological information indicates the presence of coarse aggregate near the surface of these deposits at several sites.

After deletions for cultural constraints and previous extraction, Selected Resource Area 1 has approximately 840 acres (340 ha) currently available for aggregate extraction. Based on average deposit thicknesses of 15 feet (5 m), the deposits contain an estimated 32 million tons (29 million tonnes) of sand and gravel. The deposits are easily accessible from King's Highway 10 and various county and township roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Three outwash sand and gravel deposits, designated 2a, 2b and 2c in central Holland Township, make up Selected Sand and Gravel Resource Area 2. The combined area of the deposits is 1040 acres (420 ha), exclusive of the licenced property.

Area 2a is located west of Robson Lakes. Two unlicenced pits (pit nos. 46 and 47) and part of licenced pit no. 5 have been opened in this deposit. Faces in pit no. 5 ranged in height from 10 to 15 feet (3 to 5 m) and contained an estimated 40 to 80 percent gravel. At the time of field investigation, pit-run aggregate, G.B.C. A, and 16 and 19 mm crushed stone were being produced from the pit. Other products included winter, concrete and masonry sand. Crushing and screening operations were established on the property.

The M.T.C. has tested the aggregate exposed in pit nos. 5 and 47. The pits are rated as being able to produce granular base course, and 16 mm Crushed Type A and B (Deike 1982). Soft, porous dolostone and clay-coated gravel may be present in sections of the pits. These materials restrict the quality of the gravel for high-specification uses and selective extraction procedures may be necessary to produce these products. The pits also contain oversize clasts which should be removed or crushed in a primary crusher for G.B.C. C. Blending would be required to produce asphaltic sand. Information from M.T.C. is presently unavailable for pit no. 46, however, the 8-foot (2 m) faces in the pit contained approximately 50 percent gravel.

Similar material may exist in Areas 2b and 2c. Although no pits have been developed in these two deposits, they are closely related to Area 2a in terms of geological origin. Geological data also reveal that gravel is the predominant surficial material at several sites investigated in the deposits.

After deletions have been made for cultural setbacks and previous extraction, Selected Resource Area 2 has approximately 860 acres (350 ha) currently available for extraction. Based on average deposit thicknesses of 12, 15 and 10 feet (4, 5 and 3 m), respectively, the deposits contain an estimated 28 million tons (25 million tonnes) of sand and gravel. Resource Area 2 is easily accessible from King's Highway 10 and various township roads.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

An ice-contact deposit located southwest of Arnott has been selected at the secondary level of significance. It contains unlicenced pit nos. 36 to 39. Faces in pit nos. 36 to 38 range in height from 10 to 20 feet (3 to 6 m) and expose predominantly gravel. These pits are rated by M.T.C. as being able to produce granular base course, 16 mm Crushed A and B, and Hot-Laid Nos. 4 and 8 stone (Deike 1982). Pit no. 36 contained hard, sound aggregate, but in pit nos. 37 and 38 the gravel quality was borderline for hot-laid asphalt and selective extraction would be required to produce this product. Oversize clasts were present in these pits and blending would be required for asphaltic sand. In addition, an excessive clay content was noted in pit no. 38. Data obtained from M.T.C. for pit no. 38 indicate that it contains a lower percentage of gravel than the other sources. The aggregate in this pit is rated as acceptable for granular base course and 16 mm Crushed B.

A second ice-contact gravel deposit, located east of Arnott, contains licenced pit no. 3 and pit no. 29. Deike (1982) reports that the deposit is situated in an area where the gravel quality is generally good, but varying quantities of soft, porous dolostone are known to exist. In excessive amounts, this lithology can restrict use of the gravel in hot-laid asphalt and structural concrete. The aggregate is suitable, however, for G.B.C. A and various pit-run products.

The M.T.C. has placed several test holes in the vicinity of pit nos. 3 and 29. Considerable quantities of gravel were encountered, but in a number of test holes silt and clay layers were present which would probably necessitate selective extraction procedures. The sand fraction of the aggregate in these pits would require that extracted material be blended for use in hot-laid asphalt.

Three pits have been opened in the outwash gravel deposit located near Williams Lake. Pit nos. 40 and 42 were found to be rehabilitated and overgrown, respectively. Pit no. 41 has a face height of 10 to 15 feet (3 to 5 m) and contained an estimated 20 to 47 percent gravel. A sample was taken from the pit and, upon analysis, contained 47 percent gravel, 51 percent sand, and 2 percent fines. The results of the gradation analysis are shown in Figures 2a and 2b. The gradation curves indicate that the sampled material may be suitable for some granular base course, asphaltic sand and concrete sand products. Data obtained from M.T.C. also show that the pit is acceptable for the production of granular base course as well as 16 mm Crushed B.

Northwest of Robson Lakes there are three outwash deposits which have also been selected at the secondary level. Three pits have been opened in the deposits. Ten- to fifteen-foot (3 to 5 m) faces were observed in pit no. 32 which exposed sandy fine to coarse gravel. The pit contained approximately 20 to

50 percent gravel and minor amounts of oversize material and clay-coated gravel were present. Pit nos. 33 and 34 had 2- to 12-foot (1 to 4 m) faces and were overgrown.

An ice-contact gravel deposit located adjacent to the above three outwash deposits contains pit no. 35. When investigated in the field, the pit had 15- to 25-foot (5 to 8 m) faces which exposed sandy fine to coarse gravel. The gravel content was estimated to be 40 to 70 percent. Several potential workability problems were observed including occasional silt and clay coatings on the gravel, minor cementation, and the presence of several oversize boulders. Porous dolostone was also noted in the pit. Although the aggregate is generally acceptable for a range of aggregate products, these potential workability and quality problems may restrict high- specification use of the material.

The outwash gravel deposit located east of Holland Centre contains pit no. 48. Faces in the pit ranged from 5 to 10 feet (1.5 to 3 m) high and contained 10 to 40 percent gravel. Water wells also indicate the presence of granular materials. This deposit may contain aggregate similar to that found in Selected Resource Area 2. However, further testing would be required.

Two pits have been opened in the ice-contact gravel deposit located to the east of this last outwash deposit. Pit 52 had 10- to 15-foot (3 to 5 m) faces and, at one time, produced G.B.C. A, B, and C. The pit is currently listed as depleted by M.T.C. Pit 53 had a 10- to 18-foot (3 to 6 m) face and contained 40 to 70 percent gravel. The good quality gravel in this pit is generally suitable for use as granular base course, 16 mm Crushed A and B, and Hot-Laid Nos. 4 and 8 stone (Deike 1982). Oversize material was present in the pit and the sand requires blending to produce a satisfactory hot-laid product. The swampy nature of the southwest part of the deposit may inhibit extraction of the material.

Two small deposits are located north of Berkeley. One deposit contains outwash gravel and the other contains ice-contact gravel. Pit no. 54, located in the outwash deposit, had a 10- to 12-foot (3 to 4 m) face and contained 30 to 50 percent gravel. The ice-contact deposit contains pit no. 55 which had a 15-foot (5 m) face and exposed sandy fine gravel.

Four small gravel deposits are located along Hamilton Creek east of Williamsford. Although there are no pits in these deposits, water well data for two of these deposits indicate between 16 and 49 feet (5 and 15 m) of granular material. A range of aggregate products may be produced.

An ice-contact deposit in the southwestern corner of the township is the extension of a secondary area in neighbouring Sullivan Township. Although little data exist for the section of the deposit in Holland, M.T.C. data for the Sullivan section indicate that several road-building products can be extracted from the deposit.

The final area selected at the secondary level of significance is a small gravel esker located south of Walters Falls. No pits have been developed in this esker, however, up to 18 feet (5 m) of coarse gravel was exposed in an adjacent esker situated within licenced pit no. 1. Water wells also indicate the presence of gravel.

BEDROCK GEOLOGY

Holland Township is underlain by six bedrock units of Ordovician and Silurian age. The oldest unit is the Upper Ordovician shale of the Queenston Formation, which is overlain by the Lower to Middle Silurian Manitoulin, Cabot Head, Fossil Hill, Amabel, and Guelph Formations. The distribution of, and the contacts between the various formations are shown on Map 3.

The Queenston Formation, which forms the base of the Niagara Escarpment, underlies the Bighead Valley in northern Holland Township. Water well data show that the drift overlying the formation reaches depths of over 237 feet (72 m). The Queenston Formation is predominantly red, thinly bedded shale, with occasional beds of green mottled shale (Liberty and Bolton 1971). Although the Queenston Formation is an important source of material for use in the clay products industry, it has not been selected for resource protection in Holland Township because of the thick drift cover.

The Manitoulin Formation overlies the Queenston Formation and occurs in an area surrounding the Bighead Valley. In this general area, the Manitoulin Formation consists of thick- to thin-bedded, grey, argillaceous, dolomitic limestone with shale partings and lenses of white chert (Vos 1969). In the past, the Manitoulin Formation was quarried in the eastern part of the City of Owen Sound for crushed stone, rubble, and foundation stone (Vos 1969). In Holland Township the formation is generally covered by more than 25 feet (8 m) of drift, and is of sufficiently limited extent that it is mapped together with the overlying Cabot Head Formation. The Manitoulin Formation has not been selected for possible resource protection.

The Cabot Head Formation is predominantly a grey shale interbedded with dense grey calcareous sandstone and limestone (Vos 1969). Subsurface drilling indicates the upper part of the formation consists of shale, overlying interbedded shale and silty dolostone (Johnson et al. 1983). The thickness of the formation in the area ranges from 37 to 135 feet (11 to 41 m) (Liberty and Bolton 1971). The Cabot Head shale is too soft for use as load-bearing aggregate. The formation is generally suitable for use as expanded aggregate, brick, and tile, but it has not been used for these purposes because exposures suitable for quarrying are scarce (Vos 1969). The Cabot Head shale has not been selected for possible resource protection in Holland Township because it is of limited extent, and is generally overlain by more than 25 feet (8 m) of drift.

The Cabot Head shale is overlain by the thin-bedded, brown, fine- crystalline dolostone of the Fossil Hill Formation. The formation is approximately 8 feet (2 m) thick south of Owen Sound (Vos 1969), and is of very limited extent. The formation has been mapped together with the overlying Amabel Formation on Map 3 because of its limited extent.

The Amabel Formation underlies a considerable area in northern Holland Township. The formation, in

this area, largely consists of light buff to blue, finely crystalline dolostone containing minor coarse crystalline dolostone and porous zones (Liberty 1966; Liberty and Bolton 1971). The Amabel Formation is suitable for use in crushed stone, concrete aggregate, building stone and as raw material for lime manufacture. The Amabel is considered an aggregate source of provincial significance because of its generally high quality. Those areas of the Amabel Formation that are overlain by less than 25 feet (8 m) of drift in Holland Township have been selected for possible resource protection.

The Amabel Formation often contains an abundance of reefs which are commonly 50 to 60 feet (15 to 18 m) in height and a few hundred feet in diameter (Hewitt 1960). In Holland Township the numerous "islands" of Amabel dolostone overlain by 0 to 3 feet (0 to 1 m) of drift on Map 3 are believed to be reefs (B.H. Feenstra, Mineral Resources Geologist, Ontario Ministry of Natural Resources, London, personal communication, 1982). Reef rock from the Amabel Formation is highly porous (and therefore absorptive), softer and less durable than the surrounding rock, and may contain clay pockets and iron staining, particularly near the surface (Hewitt 1960). For these reasons the quality of the reefal rock may be impaired for use as aggregate. However, the inter-reef rock deposited between the reefs is of high quality and is well suited for extraction and use. Extractive operations are, therefore, better located in the inter- reef areas. The Guelph Formation underlies the majority of the township. The formation consists of tan to brown, fine- to medium- crystalline dolostone which appears vuggy and porous in reefal complexes (Liberty 1966). The formation has a high chemical purity and is a valuable raw material for numerous metallurgical products. It is quarried for the manufacture of dolomitic lime near Guelph and Hamilton. In the area of Holland Township, the formation is very pure, generally possessing less than one percent impurities. However, a lack of immediate local markets limits its use at the present (B.H. Feenstra, personal communication, 1982). The soft and porous reefal strata make the Guelph Formation generally unsuitable for use as load-bearing aggregate. A high water table and the karstic condition of the formation in Holland Township are further limiting factors.

SELECTED BEDROCK RESOURCE AREAS 1 AND 2

Selected Bedrock Resource Areas 1 and 2 consist of those areas of the Amabel and Fossil Hill Formations overlain by less than 25 feet (8 m) of drift. The resource areas are located in north-central and northeastern Holland Township. They occupy a total of 4700 acres (1900 ha), 3750 acres (1520 ha) of which are estimated to be available for extraction. Assuming an average workable thickness of 60 feet (18 m), presently available crushed stone resources are approximately 810 million tons (740 million tonnes).

The Amabel dolostone is generally well suited for the production of a variety of aggregate products. The formation has also been quarried for building stone, and because of its high purity is a valuable source of lime. Although no quarries have been opened in Holland Township, Amabel dolostone was extracted from several quarries in the vicinity of the City of Owen Sound at the turn of the century. These quarries produced lime, building stone and crushed stone (Goudge 1938).

Parts of the two resource areas fall within the planning area of the Niagara Escarpment Commission. The location and establishment of extractive operations would be subject to the policies of the commission which should be consulted prior to the development of any particular site.

SUMMARY

The sand and gravel resources of Holland Township were deposited during the Great Ice Age. Two areas of outwash gravel have been selected for possible resource protection at the primary level. These resource areas contain good quality aggregate suitable for use in road-building and construction products. In addition, several ice- contact, outwash, and esker deposits have been selected at the secondary level. These deposits are also important parts of the total aggregate supply.

Surficial materials in Holland Township are underlain by bedrock of the Queenston, Manitoulin, Cabot Head, Fossil Hill, Amabel and Guelph Formations. The Amabel Formation is the best suited of these formations for use as load-bearing and construction aggregate, and in areas where the drift is less than 25 feet (8 m), it has been selected for possible resource protection.

Enquiries regarding the Aggregate Resources Inventory of Holland Township should be directed to the Ontario Ministry of Natural Resources, either at the Owen Sound District Office, 611 - 9th Avenue East, Owen Sound, Ontario, N4K 3E4 (Tel. (519) 376-3860) or at the Southwestern Region Geological Office, 458 Central Avenue, London, Ontario, N6B 2E5 (Tel. (519) 433-8431).

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, HOLLAND TOWNSHIP.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
1	S-E	26 (10)	2 (2)
	S-IC	1400 (570)	70 (64)
2	G-E	57 (23)	2 (2)
	S-E	173 (70)	5 (4)
	S-IC-E	40 (16)	1 (1)
	G-IC	1250 (510)	45 (41)
	S-IC	4950 (2000)	160 (145)
	G-OW	3150 (1280)	105 (95)
	S-OW	1380 (560)	37 (34)
3	S-E	42 (17)	1 (1)
	G-IC	49 (20)	1 (1)
	S-IC	1490 (600)	30 (27)
	S-IC-E	12 (5)	<1 (<1)
	S-LP	1430 (580)	29 (26)
	G-OW	1770 (720)	35 (32)
	S-OW	1500 (610)	30 (27)
	S-OW-LP	360 (146)	7 (6)
4	G-IC	110 (44)	1 (1)
	S-IC	32 (13)	<1 (<1)
	G-OW	20 (8)	<1 (<1)
	S-OW	27 (11)	<1 (<1)
		19,300 (7800)	560 (510)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 2. SAND AND GRAVEL PITS, HOLLAND TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
LICENCED PITS							
1	-	Josephine Spretnjak	W1/2 5	12	99.8 (40.4)	5-10 (1.5-3)	5-40
2	-	Harold Sutherland	E1/2	12	12.3 (5.0)	10-15 (3-5)	10-45
3	M4-132	Seeley & Arnill Const. Ltd.	Pt.5,6, 7	1ETSR	53.7 (21.7)	5-10 (1.5-3)	30-70
4	-	107403 Canada Inc.	Pt.11, 12	3ETSR	55.0 (22.3)	10-45 (3-14)	10-40
5	M4-129	Mac Taylor Contracting Limited	Pt.11, 12	9	243.8 (98.7)	10-15 (3-5)	40-80
6	-	Arthur Routenburg	Pt.58	3	31.3 (12.7)	25-30 (8-9)	25-40
					495.9 (200.7)		
UNLICENCED PITS*							
7	-	Unknown	1	1		10 (3)	10-25 partially overgrown
8	-	Bohusz	2	2		5-12 (1.5-4)	10-35
9	M4-3	A. Watson	1&2	1E		5-15 (1.5-5)	10-20 partially overgrown
10	M4-6	Carson	2	1E		10-15 (3-5)	10-25 partially overgrown
11	M4-28	Carson	3	1E		15-20 (5-6)	5-15
12	-	Unknown	3	6		5-10 (1.5-3)	-
13	-	Unknown	4	6		10-15 (3-5)	0-10 partially overgrown
14	-	Unknown	3	10		5-7 (1.5-2)	20-40
15	M4-19	Hamill	2	11		3-6 (1-2)	30-40 partially overgrown
16	-	Unknown	2	11		11 (3)	-
17	M4-15	Seebrook	1	11		25-30 (8-9)	- partially slumped
18	-	Unknown	16	2		7-16 (2-5)	10-20 partially overgrown

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

*Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 2. SAND AND GRAVEL PITS, HOLLAND TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
19	-	Unknown	5	4		5-10 (1.5-3)	40 partially overgrown
20	M4-110	Givens	1	3ETSR		10-15 (3-5)	2-80 overgrown
21	M4-26	A. Morrison	A	4		5-15 (1.5-5)	0-70
22	M4-7	Mathews	6	4		5 (1.5)	- overgrown
23	M4-74	W.J. Hill	6	5		5-20 (1.5-6)	10-75 partially overgrown
24	-	Unknown	5	3ETSR		5-10 (1.5-3)	10-30
25	-	Unknown	7	9		10-20 (3-6)	- partially overgrown
26	-	S.R. Mustard	5	9		15 (5)	5-15
27	-	Unknown	7	12		15 (5)	- overgrown
28	-	Unknown	7	12		5-12 (1.5-4)	5-20 partially overgrown
29	M4-144	E. Givens	2,3,4	1ETSR		-	20-75
30	-	Unknown	12	2ETSR		10 (3)	- overgrown
31	-	Unknown	10	3ETSR		20-25 (6-8)	- partially overgrown
32	-	Unknown	20	3ETSR		10-15 (3-5)	20-50 partially overgrown
33	-	Unknown	20	4ETSR		3-4 (1-1.2)	- overgrown
34	-	Unknown	10	7		10-12 (3-4)	-
35	-	Unknown	23	4ETSR		15-25 (5-8)	40-70 partially overgrown
36	M4-29	D. MacLeod	12	1E		17-20 (5-6)	25-70 partially overgrown
37	M4-65	C. Wheildon	28	2		15-20 (5-6)	- overgrown
38	M4-16	McNabb	29	2		10-20 (3-6)	50-70
39	M4-39	McGuiness	27	2		10 (3)	10
40	-	Unknown	10	1WTSR		11 (3)	- rehabili-tated

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 2. SAND AND GRAVEL PITS, HOLLAND TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
41	M4-40	Sylviski (Curtis)	13	1WTSR		10-15 (3-5)	20-47
42	-	Unknown	19	2WTSR		7-10 (2-3)	- overgrown
43	-	Unknown	22	3ETSR		15 (5)	0-10 partially overgrown
44	-	Unknown	22	3ETSR		7-10 (2-3)	5-15 slumped
45	-	Unknown	25	2ETSR		10-12 (3-4)	20-30 slumped
46	-	Unknown	13	9		8 (2)	50 slumped
47	M4-125	Georgian Bay Lutherian Cluster	13	9		7-12 (2-4)	50-70 partially overgrown
48	-	Unknown	39	3ETSR		5-10 (1.5-3)	10-40 partially overgrown
49	-	Unknown	16	10		5-10 (1.5-3)	20-40 slumped
50	-	Unknown	16	12		6 (2)	- overgrown
51	-	Unknown	15	12		5-10 (1.5-3)	20-40 partially overgrown
52	M4-134	Seeley & Arnill	44	1ETSR		10-15 (3-5)	- depleted
53	M4-80	Holley Const. Ltd.	45	1ETSR		10-18 (3-6)	40-70
54	-	Unknown	50	2ETSR		10-12 (3-4)	30-50 partially overgrown
55	-	Unknown	54	2ETSR		15 (5)	- overgrown
56	-	Unknown	61	3ETSR		12 (4)	- overgrown
57	M4-24	Musall	24	1E		10-30 (3-9)	0-30 overgrown
58	-	Unknown	54	2		15-20 (5-6)	- overgrown
59	-	Unknown	53	2		4 (1.2)	25-30
60	-	Unknown	54	2		10-12 (3-4)	25 partially overgrown
61	-	Unknown	25	5		30 (9)	5-10 slumped
62	-	Unknown	45	2WTSR		10-20 (3-6)	30-40 partially overgrown
63	-	Unknown	23	6		5-10 (1.5-3)	- slumped

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 2. SAND AND GRAVEL PITS, HOLLAND TOWNSHIP.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet Metres	8 % Gravel
64	M4-120	J. Geerts	60	2WTSR		5-10 (1.5-3)	60-75
65	-	Unknown	62	2WTSR		5-7 (1.5-2)	50-60 partially overgrown
66	M4-107	Semple	62	1WTSR		5-20 (1.5-6)	50-75 partially overgrown
67	-	Unknown	22	12		-	35-50 overgrown
68	-	Unknown	23	12		5 (1.5)	- partially overgrown
69	M4-67	E.& E. Seegmiller	25	1E		15 (5)	- overgrown
70	M4-77	Coutts	28	1E		10 (3)	60-80 overgrown
71	-	Unknown	27	7		5-10 (1.5-3)	40-50 partially overgrown
72	-	Unknown	28	8		7-12 (2-4)	5-40 slumped
73	-	Unknown	70	3WTSR		5-8 (1.5-2)	10-50 slumped
74	-	Unknown	75	1WTSR		8-10 (2-3)	- partially overgrown
75	M4-31	Twp. of Holland (Zurk)	83	1ETSR		35-50 (11-15)	25-40 overgrown
76	-	Unknown	87	1ETSR		5-12 (1.5-4)	10-20 partially overgrown
77	-	Unknown	92	1ETSR		10-12 (3-4)	10-20 slumped

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, HOLLAND TOWNSHIP.

1 Deposit No.	2 Unlicenced Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
1a	810 (330)	140 (57)	10 (4)	660 (265)	15 (5)	25 (23)
1b	245 (99)	65 (26)	5 (2)	175 (71)	15 (5)	7 (6)
	1060 (430)	205 (83)	15 (6)	840 (340)		32 (29)
2a	400 (162)	40 (16)	5 (2)	355 (144)	12 (4)	11 (10)
2b	510 (206)	105 (42)	0 (0)	405 (164)	15 (5)	15 (14)
2c	130 (53)	30 (12)	0 (0)	100 (40)	10 (3)	2 (2)
	1040 (420)	175 (71)	5 (2)	860 (350)		28 (25)
	2100 (850)	380 (154)	20 (8)	1700 (690)		60 (54)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCES, HOLLAND TOWNSHIP

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
0-3	Guelph	60	27	6
(0-1)		(18)	(11)	(5)
3-25	Guelph	60	2130	460
(1-8)		(18)	(860)	(415)
25-50	Guelph	60	12,900	2800
(8-15)		(18)	(5200)	(2550)
			15,100	3250
			(6100)	(2950)
0-3	Amabel &	60	430	93
(0-1)	Fossil Hill	(18)	(174)	(84)
3-25	Amabel &	60	4250	920
(1-8)	Fossil Hill	(18)	(1720)	(840)
25-50	Amabel &	60	3300	710
(8-15)	Fossil Hill	(18)	(1340)	(640)
			8000	1720
			(3250)	(1560)
0-3	Manitoulin &	60	2	<1
(0-1)	Cabot Head	(18)	(1)	(<1)
3-25	Manitoulin &	60	425	87
(1-8)	Cabot Head	(18)	(172)	(79)
25-50	Manitoulin &	60	1560	320
(8-15)	Cabot Head	(18)	(630)	(290)
			1990	405
			(800)	(365)
			25,000	5400
			(10 000)	(4900)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 5. QUARRIES, HOLLAND TOWNSHIP.

1 NO.	2 MTC NO.	3 OWNER/ OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)

-NONE-

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, HOLLAND TOWNSHIP.

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
1	0-25	1010	270	0	740	60	160
	(0-8)	(410)	(109)	(0)	(300)	(18)	(145)
2	0-25	3700	680	0	3000	60	650
	(0-8)	(1500)	(275)	(0)	(1210)	(18)	(590)
		4700	950	0	3750		810
		(1900)	(385)	(0)	(1520)		(740)

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

TABLE 7. SUMMARY OF TEST HOLE DATA, HOLLAND TOWNSHIP.

-NONE-

N.B. Minor variations in all tables are caused by rounding of data.
*Identified deposits within the Village of Chatsworth are omitted in all tables.

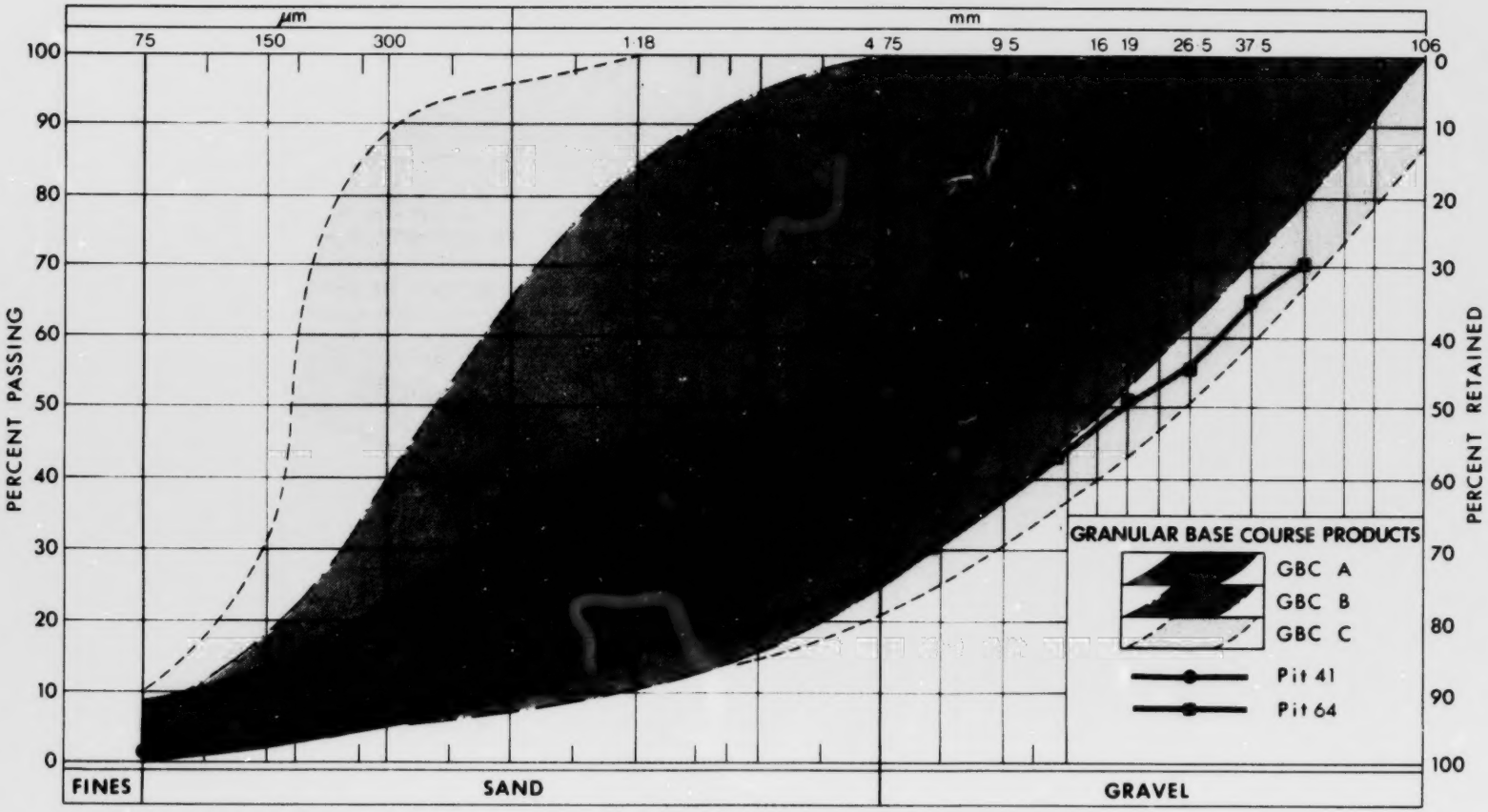


FIGURE 2a: AGGREGATE GRADING CURVES, **HOLLAND TOWNSHIP;**

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

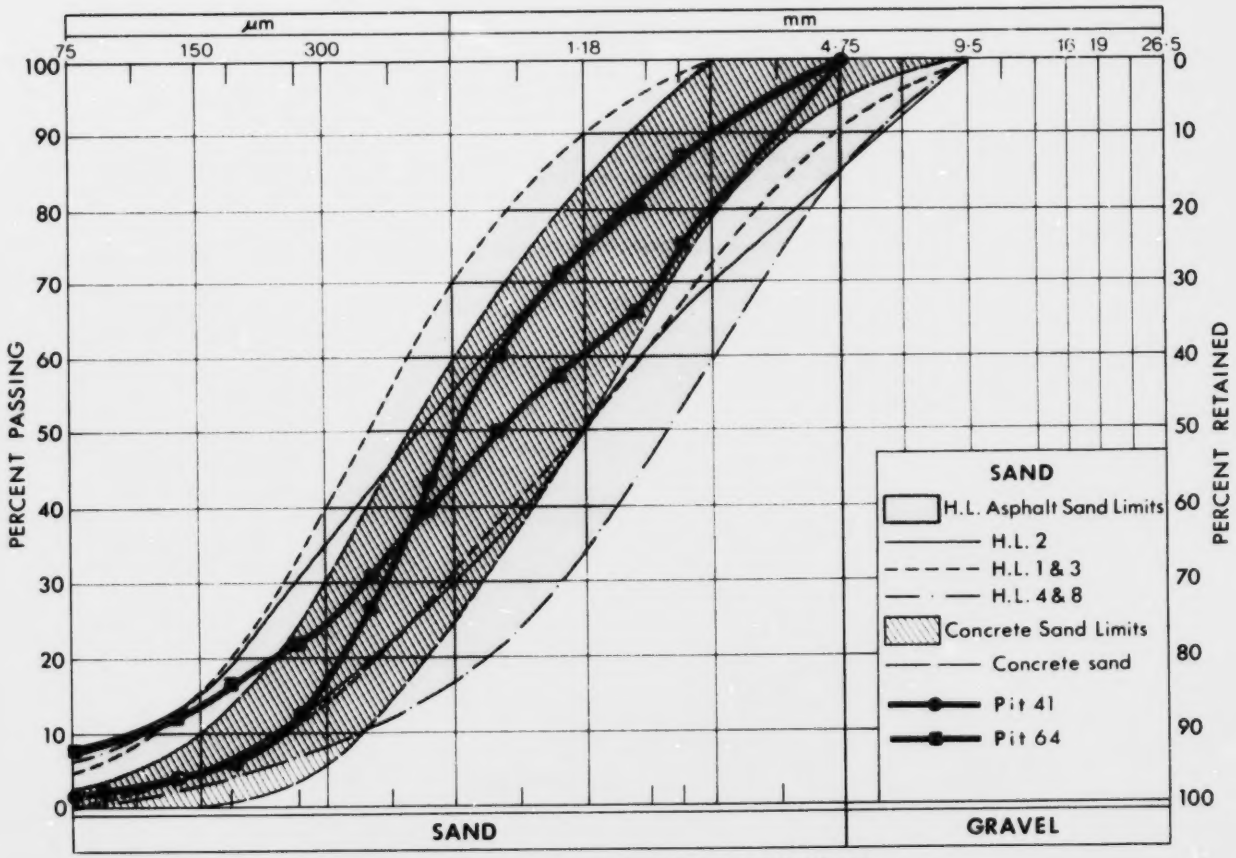


FIGURE 2b: AGGREGATE GRADING CURVES, **HOLLAND TOWNSHIP;**

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix A — Suggested Additional Reading

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Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Alkali-aggregate reaction: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Cambrian: The first period of the Palezoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: an early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near- ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probabilitiy of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

Bass Islands Formation (Upper Silurian)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18 m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunnville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate because of high soundness losses.

Bobcaygeon Formation (Middle Ordovician)

Composition: Compact, homogeneous, medium- to thin-bedded, fine- grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

Bois Blanc Formation (Lower-Middle Devonian)

Composition: Brownish grey, medium-crystalline, medium- to thin- bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High cherty content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

Dundee Formation (Middle Devonian)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys as raw material for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

Gull River Formation (Middle Ordovician)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

Lockport and Amabel Formations (Middle Silurian)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive- bedded, fine-to medium-grained dolostone. Thickness: Amabel Formation: maximum observed

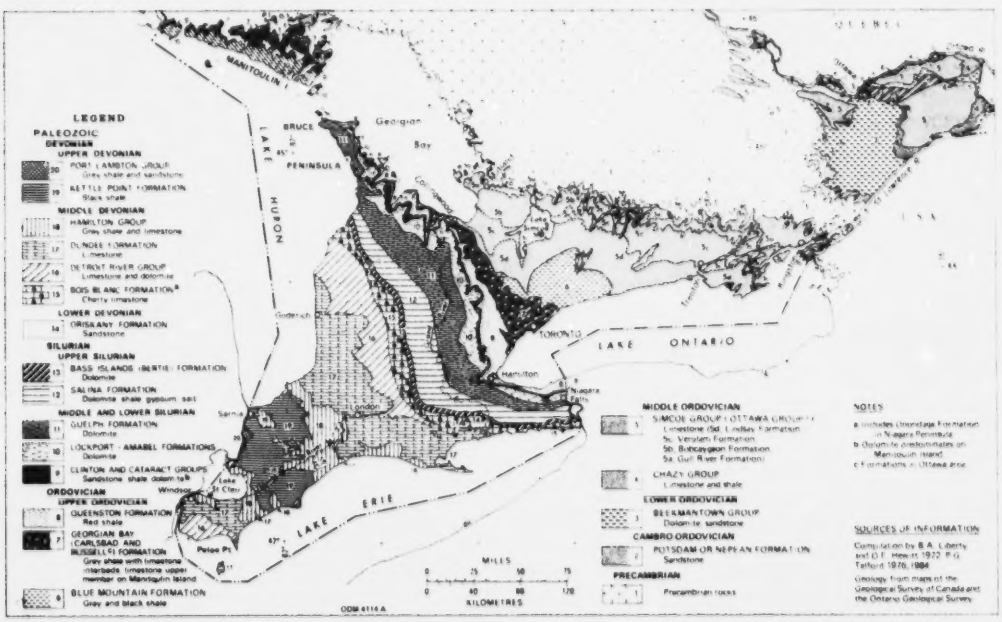


Figure 3. Bedrock Geology of Southern Ontario.

thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

Onondaga Formation (Middle Devonian)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium- grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey- brown, fine-grained, very cherty limestone having estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey-brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High cherty content makes much of the material unsuitable for concrete aggregate.

Ottawa Formation (Middle Ordovician)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of limestone for cement production and agricultural uses.

Oxford Formation (Lower Ordovician)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

Detroit River Group (Middle Devonian)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces much of Ontario's lime and cement. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

Grenville Marble (Precambrian)

Composition: Recrystallized fine- to coarse-grained white limestone and dolostone, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

Guelph Formation (Middle Silurian)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. Thickness: 100 to 170 feet (30 to 52 m). Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

Lindsay Formation (Upper Ordovician)

Composition: fine-crystalline, rubbly, nodular-weathering limestone. Collingwood Member: organic-rich interbedded calcareous shales and limestones. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

Verulam Formation (Middle Ordovician)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for use in cement manufacture. The formation is unsuitable for crushed stone because of clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

Georgian Bay Formation (Upper Ordovician) (Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue-grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in the vicinity of Metro Toronto produce brick and structural tile. Lightweight aggregate has been produced at Streetsville by heat expansion of the shale.

Hamilton Group (Middle Devonian)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona Formation is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). The Arkona Formation has a thickness of 14 to 121 feet (4 to 37 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile.

Queenston Formation (Upper Ordovician)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

Nepean (Potsdam) Formation (Cambro-Ordovician)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

Salina Formation (Upper Silurian)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

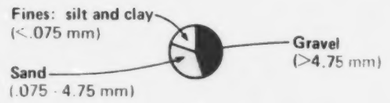
Blue Mountain Formation (Upper Ordovician)

(Formerly known as the Whitby Formation) Composition: Blue-grey, predominantly non-calcareous shale. Uses: Quarried at Bowmanville for use in cement production.

LEGEND

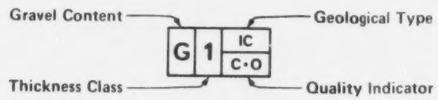
(continued from right margin)

TEXTURE SYMBOL



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in Feet (Metres)	Tons per Acre	Tonnes per Hectare
1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

If blank, no known limitations present.

C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

Ontario

Ministry of Natural Resources

Hon. Michael Harris
Minister

Mary Mogford
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

HOLLAND TOWNSHIP

GREY COUNTY

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/7

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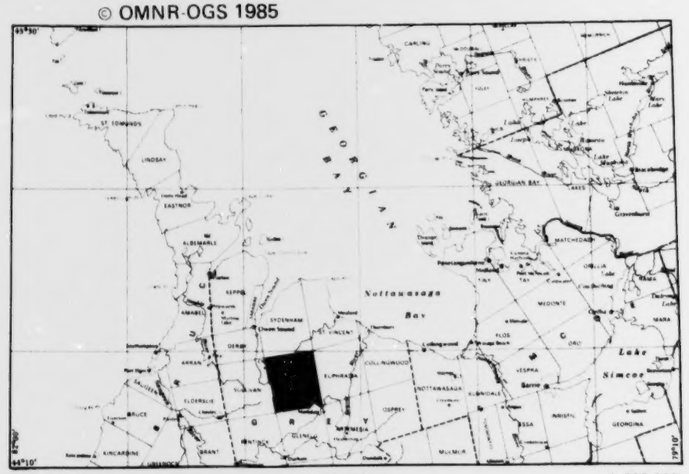


Location Map

1:800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

- Gravel deposit.
- Sand deposit.
- Gravel overlain by other surficial material.

1	greater than 20 (>6)	greater than 50,000	greater than 112 000
2	10 - 20 (3 - 6)	25,000 - 50,000	56 000 - 112 000
3	5 - 10 (1.5 - 3)	12,500 - 25,000	28 000 - 56 000
4	less than 5 (<1.5)	less than 12,500	less than 28 000

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

(see Appendix C for descriptions of Geological Types)

Quality Indicator

If blank, no known limitations present.

C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.

Selected water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: B. H. Feenstra, in prep.

Additional Field Work by: Staff of the Aggregate Assessment Office.

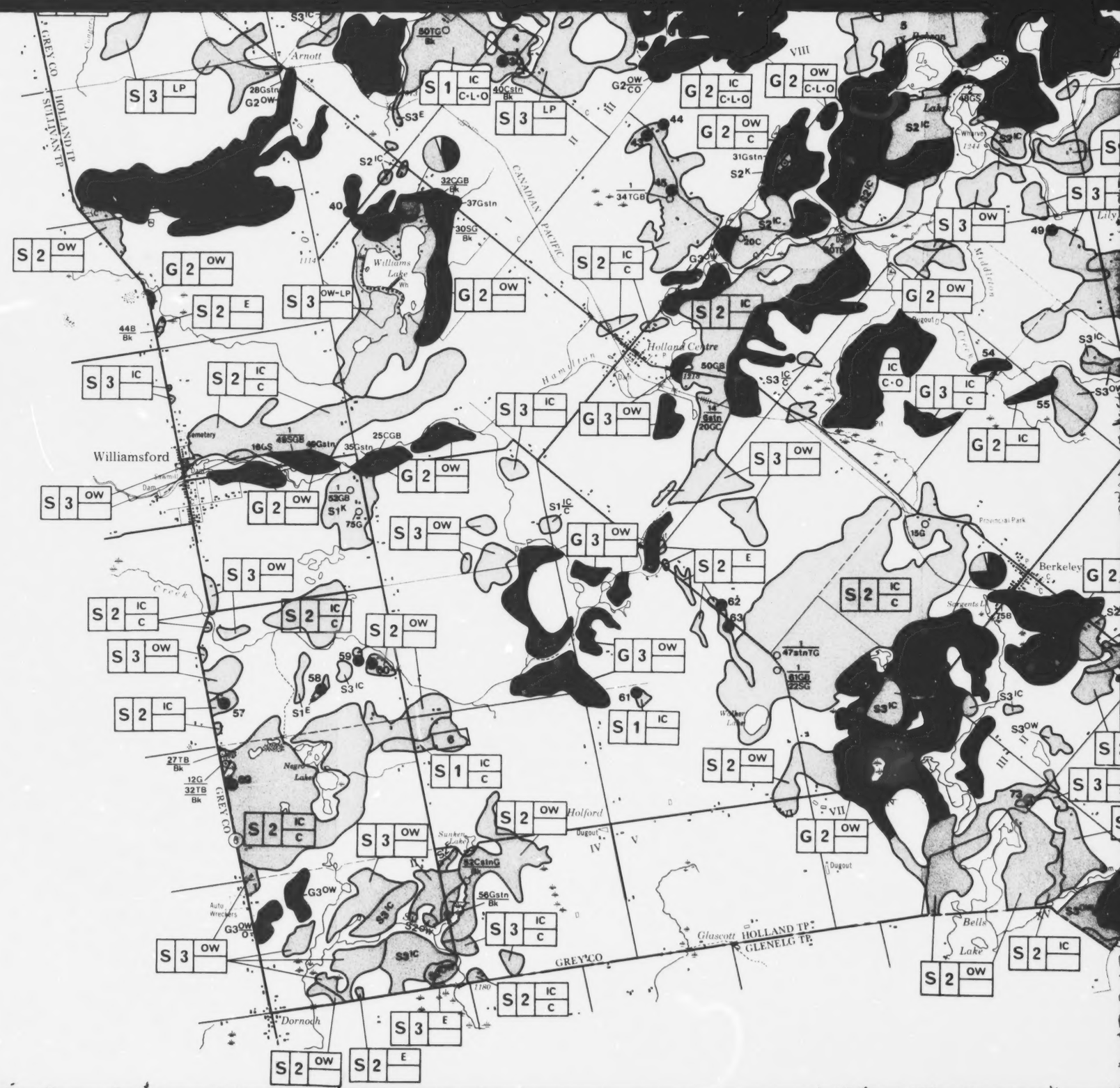
Compilation and Drafting by: Staff of the Aggregate Assessment Office.

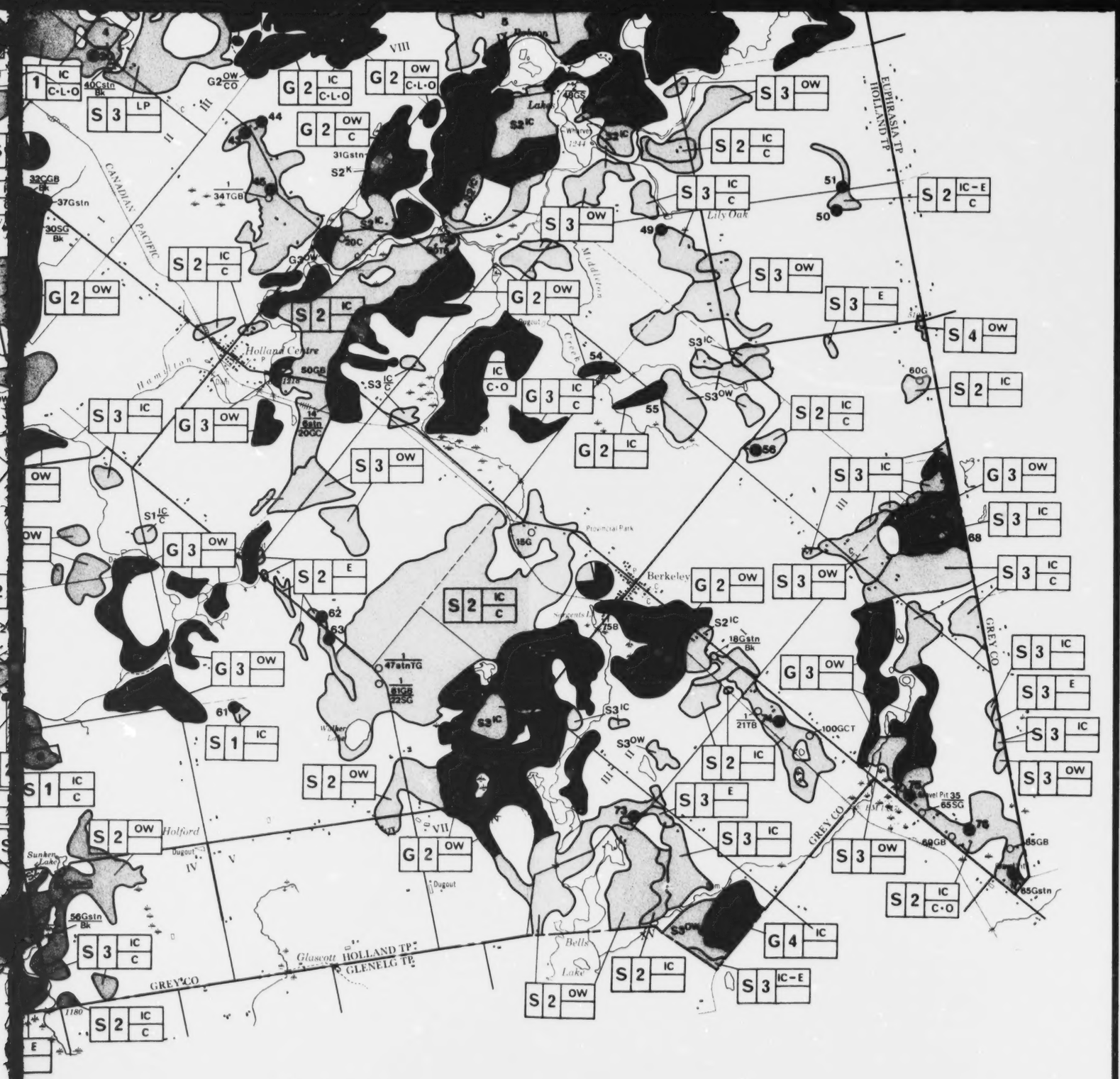
This map is to accompany O.G.S. Aggregate Resources Inventory Paper 100.

This map is published with the permission of V. G. Milne, Director, Ontario Geological Survey.

Issued 1985.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.





Location Map

LEGEND

1:800,000

(Some map units and symbols may not apply to this map.)

MAP UNITS

- Gravel deposit.
- Sand deposit.
- Gravel overlain by other surficial material.
- Sand overlain by other surficial material.
- Other surficial deposits or exposed bedrock.

SYMBOLS

- Geological and aggregate thickness boundary of sand and gravel deposits.
- Municipal boundary.
- 2 — Licenced property boundary; Property number: see Table 2.
- 3 — Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.
- HO-TH-2 — Test hole location; identification number; see Table 7.
- 6 / 24G — Selected water well location. Layers of materials are described by: reported thickness of material (in feet); reported type of material (number only - overburden, G - gravel, S - sand, C - clay, T - till, B - boulders, Bk - bedrock, stn - stones)
- G 1 IC C·O — Deposit symbol; see left margin.
- Texture symbol; see left margin; see Figures 2a & 2b.
- HO-GT-2 — Geophysical traverse line; Identification number.

(continued at left margin)

LEGEND

(continued from right margin)

DRIFT THICKNESS

Bedrock outcrop (see Table 4); areas of exposed bedrock partially covered by a thin veneer of drift. Drift thickness is generally less than 3 feet (1 m).

Bedrock covered by drift (see Table 4); drift thickness is generally 3 to 25 feet (1 to 8 m). Bedrock outcrops may occur.

Bedrock covered by drift (see Table 4); drift thickness is generally 25 to 50 feet (8 to 15 m). Isolated bedrock outcrops may occur.

Bedrock covered by drift; drift thickness is generally greater than 50 feet (15 m).

SYMBOLS

(1) Selected bedrock resource area; deposit number, see Table 6.

Geological formation boundary.

Geological formation member boundary.

Formation thickness boundary (see text).

25 Drift thickness contour. (3-foot, 25 foot and 50 foot contours are shown).

Municipal boundary.

Q2 Licenced quarry boundary; Property number: see Table 5.

Q3 Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.

x Isolated bedrock outcrop.

O 24 Selected water well location; reported depth to bedrock (in feet).

SOURCES OF INFORMATION

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Ministry of Natural Resources
Ontario

Hon. Michael Harris
Minister

Mary Mogford
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

HOLLAND TOWNSHIP

GREY COUNTY

MAP 3
BEDROCK RESOURCES

Scale 1 : 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/7

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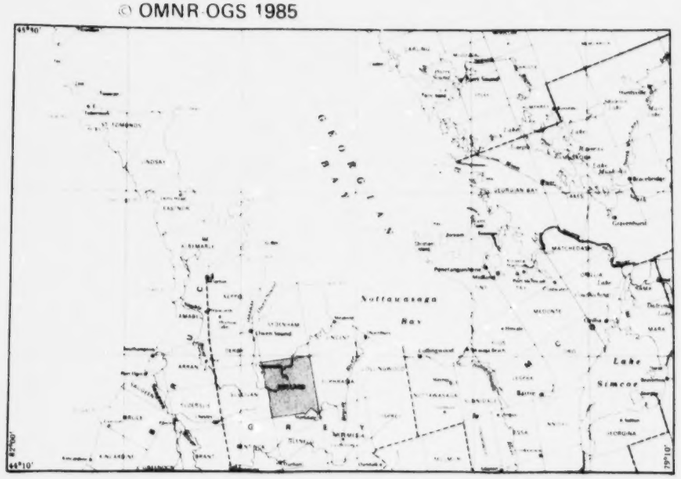

Location Map

Scale: 1:800,000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

SILURIAN

MIDDLE SILURIAN

GUELPH FORMATION

Q2 — Licenced quarry boundary; Property number: see Table 5.

● Q3 — Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.

x — Isolated bedrock outcrop.

○ 24 — Selected water well location; reported depth to bedrock (in feet).

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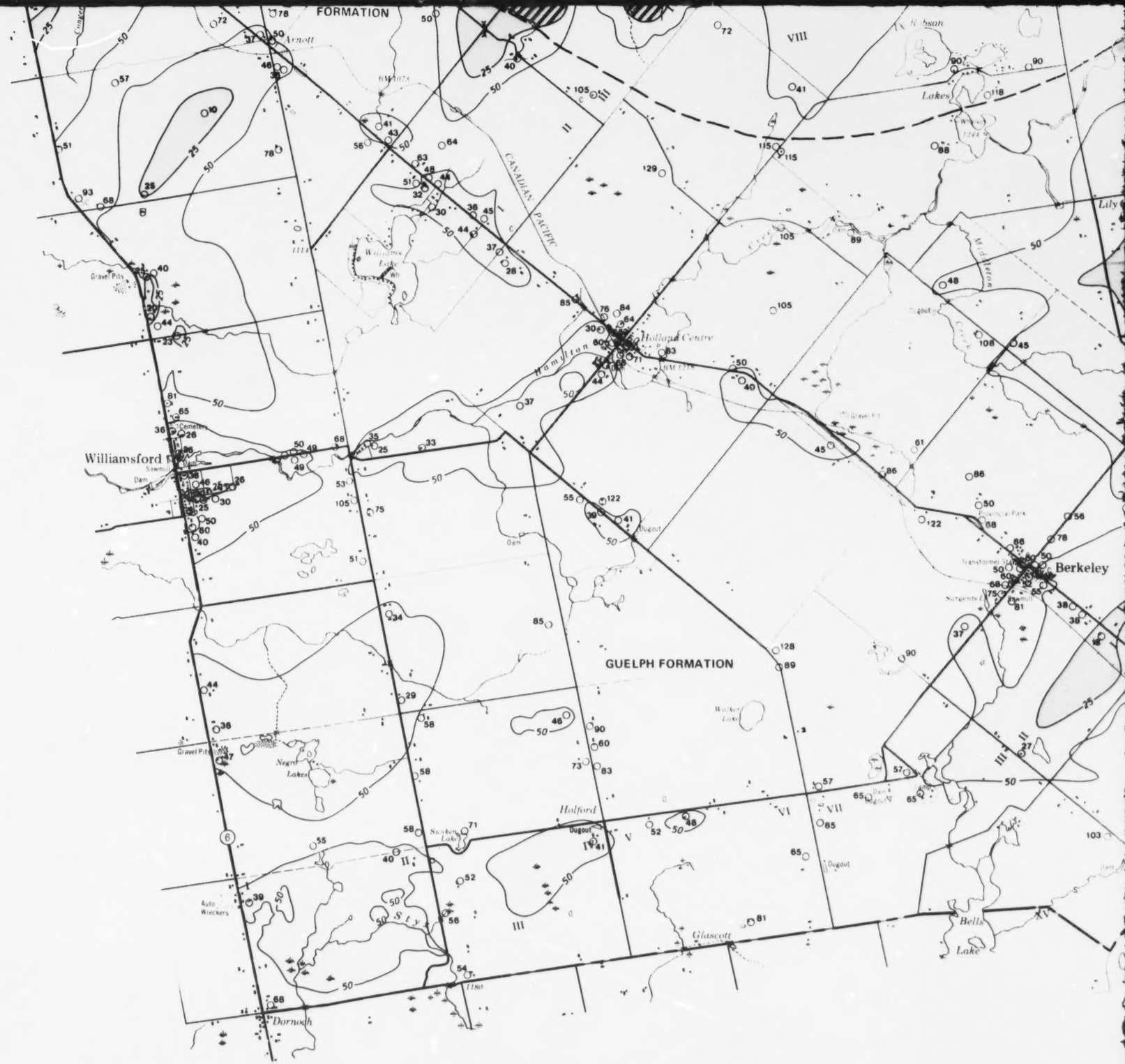

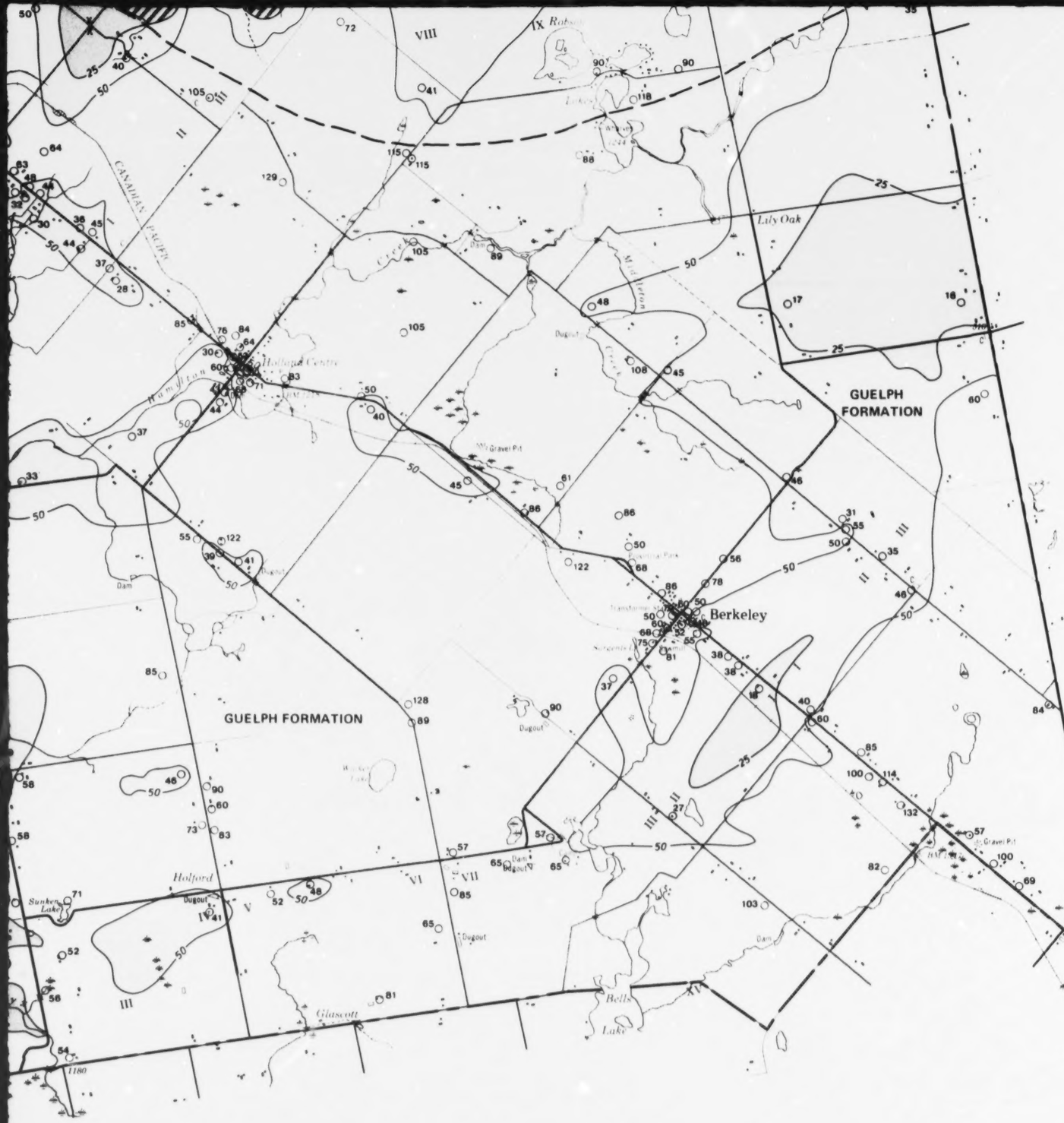

Location Map

Scale: 1:800,000

LEGEND

(Some units and symbols may not apply to this map.)

BEDROCK UNITS

PALEOZOIC

SILURIAN

MIDDLE SILURIAN

GUELPH FORMATION
Dolostone
AMABEL FORMATION
Dolostone
FOSSIL HILL FORMATION
Dolostone

LOWER TO MIDDLE SILURIAN

CABOT HEAD FORMATION
Shale
MANITOULIN FORMATION
Dolostone

ORDOVICIAN

UPPER ORDOVICIAN

QUEENSTON FORMATION
Shale

(continued at left margin)

GREY CO
SYDENHAM TP
HOLLAND TP
Chatsworth
Arnott
Holland Centre
Williams Lake
Gravel Pit
Cemetery
Dam
Lakes
Swamp
Marsh
Creek
Strathaven
Walters Falls
Elsinore
Middleton
EUPHRASIA TP
HOLLAND TP
CHATSWORTH TP
HOLLAND TP
CANADIAN PACIFIC
2a
2b
2c
N

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Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

HOLLAND TOWNSHIP

GREY COUNTY

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1: 50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 41 A/7

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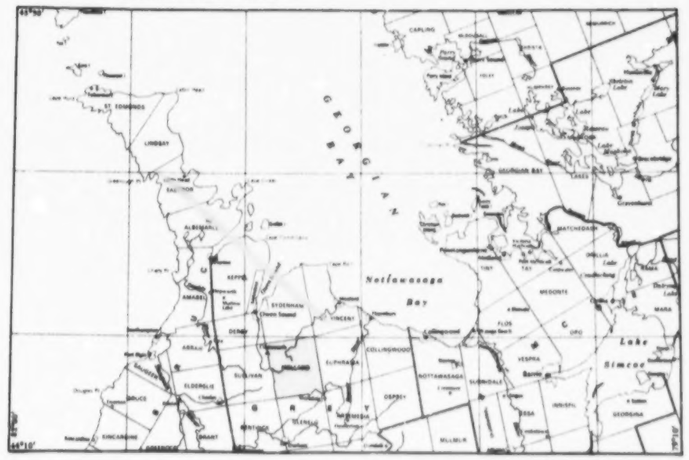


Location Map

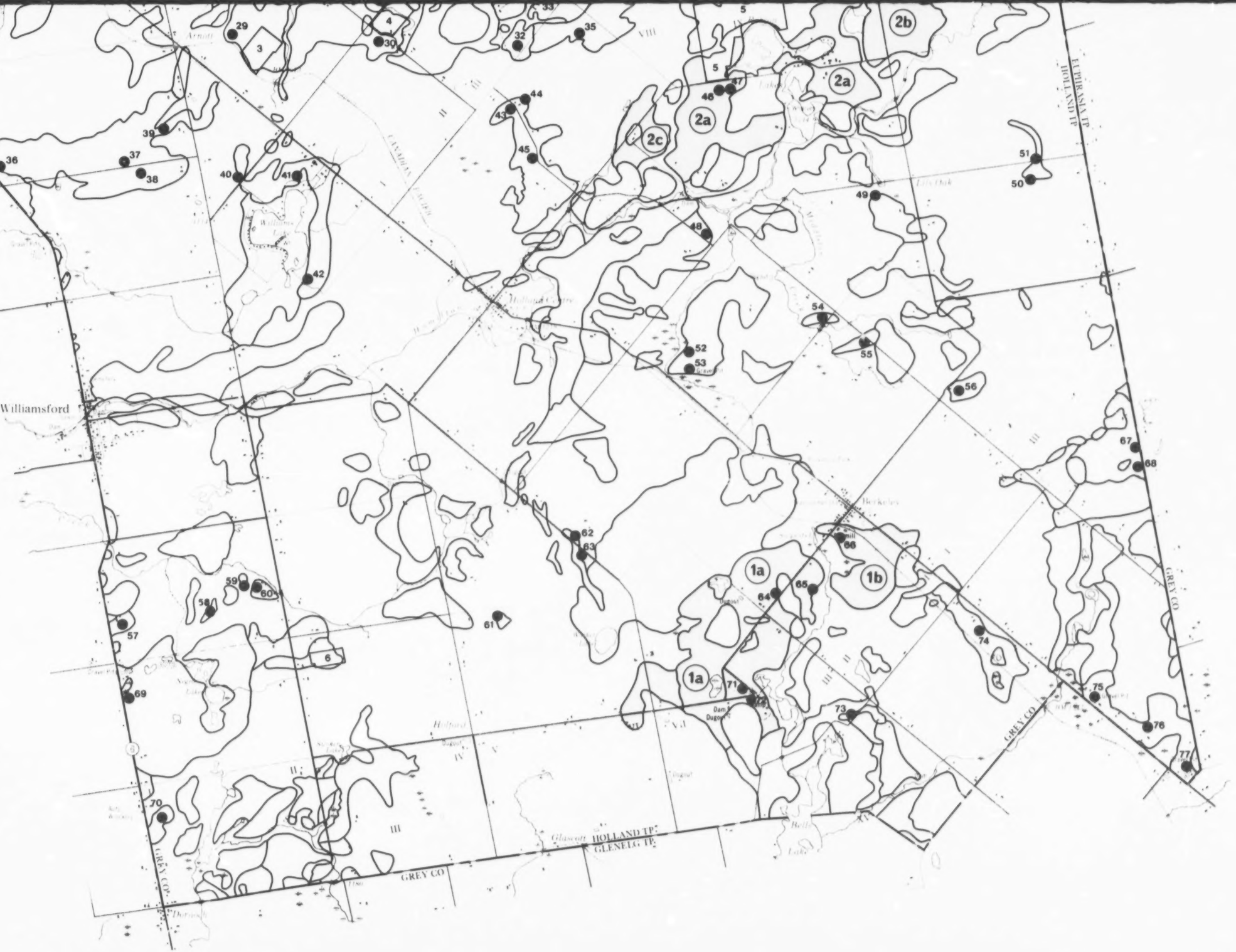
Scale: 1:800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

(1)	Selected sand and gravel resource area, primary significance; deposit number; see Table 3.
	Selected sand and gravel resource area, secondary significance.


Williamsford
HOLLAND TP
GLENELG TP
GREY CO
2a
2b
2c
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VIII
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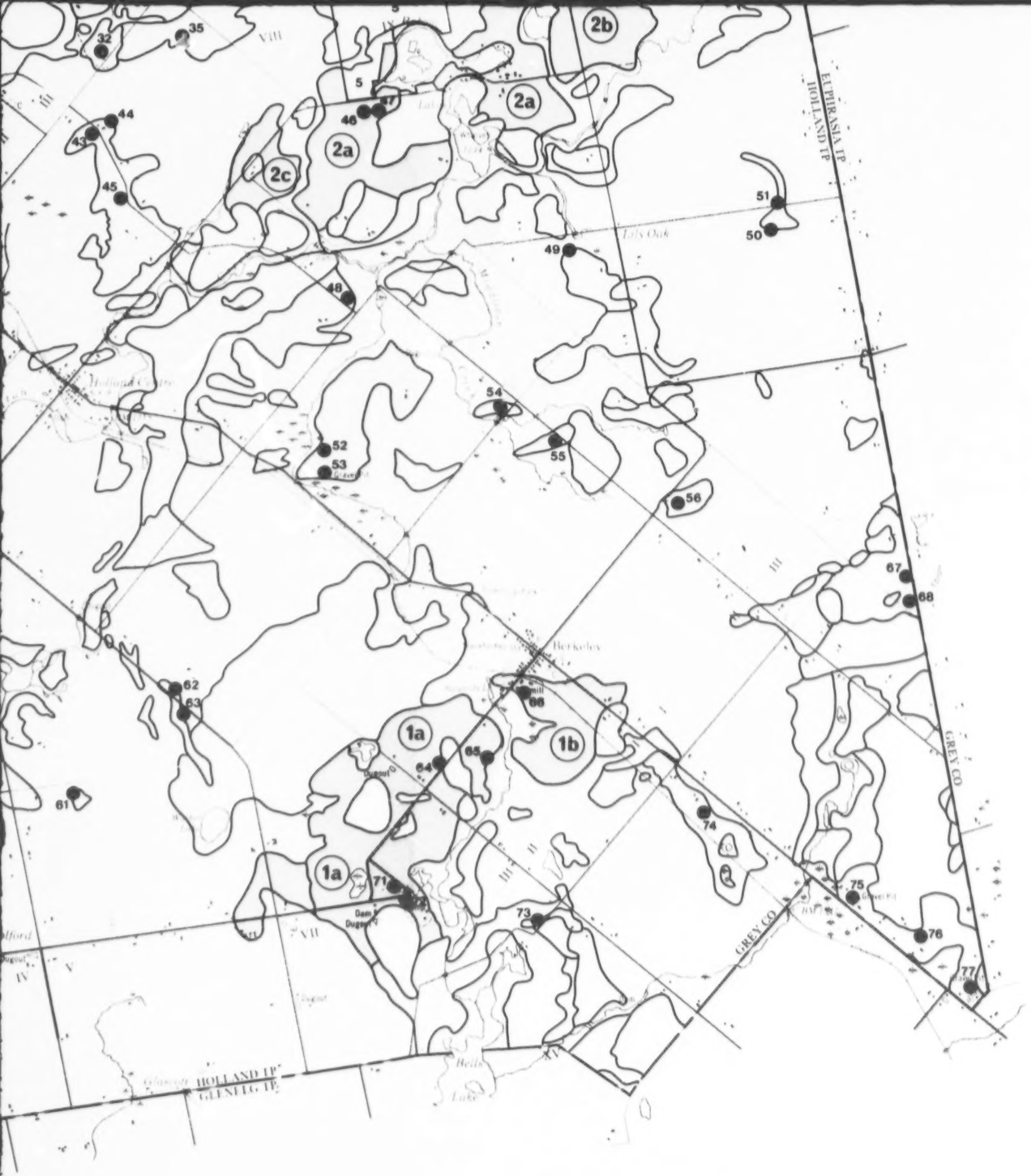

Location Map

Scale: 1:800,000

LEGEND

(Some map units and symbols may not apply to this map.)

MAP UNITS

(1)	Selected sand and gravel resource area, primary significance; deposit number; see Table 3.
	Selected sand and gravel resource area, secondary significance.
	Selected sand and gravel resource area, tertiary significance.

SYMBOLS

———	Geological and aggregate thickness boundary of sand and gravel deposits.
— — —	Municipal boundary
2	Licenced property boundary; Property number: see Table 2.
● 3	Unlicenced sand or gravel pit*; Property number: see Table 2. *Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Geology by: B. H. Feenstra, in prep.

Additional Field Work by: Staff of the Aggregate Assessment Office.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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